How do the health outcomes of a vegetarian diet compare to that of a diet which customarily includes animal products?

Conclusion

Limited evidence is available documenting that vegetarian diets protect against cancer. However, it suggests that vegetarian, including vegan diets, are associated with lower body mass index and blood pressure. Vegan diets may increase risk of osteoporotic fractures. The effect of vegetarian diets on cardiovascular disease, stroke and mortality are discussed further in ***Part B. Section 2: The Total Diet: Combining Nutrients, Consuming Food***.

Grade: Limited

Overall strength of the available supporting evidence: Strong; Moderate; Limited; Expert Opinion Only; Grade not assignable For additional information regarding how to interpret grades, click here.

Evidence Summary Overview

Eighteen studies published since 2000 were reviewed that represented eight countries (Alewaeters, 2005; Appleby, 2002; Appleby, 2007; Baines, 2007; Chen, 2008; Dos Santos Silva, 2002; Grant, 2008; Hung, 2006; Key, 2009a; Key, 2009b; Newby, 2005; Nakamoto, 2008; Rosell, 2006; Spencer, 2003; Teixeira, 2007; Thorpe, 2008; Wang, 2008d; Yen, 2008). Most studies in this review were of a weaker design, including cross-sectional and case-control studies. Only five articles were prospective cohort studies and no randomized controlled trials (RCTs) were identified. Six articles provided results from the EPIC study from the United Kingdom and four studies were conducted in Taiwan. Other countries represented were the US, Australia, Japan, Sweden, Belgium and Brazil. Vegetarian diets varied greatly among countries and classifications of plant-based diets were inconsistent among studies. However, all studies compared the health outcomes observed between individuals who regularly consumed animal products to those who occasionally, rarely or never consumed animal products.

In the EPIC cohort, vegetarian, particularly vegan, diets were associated with lower body mass index (BMI) and lower levels of obesity than diets that included meat (Spencer, 2003). Similar results were found in the Swedish Mammography Cohort (Newby, 2005). Rosell et al, (2006) reported on five-year changes in weight in the EPIC cohort by dividing participants into groups based on their eating patterns. Specifically, they examined whether participants maintained the same diet (e.g., vegan) over time, or reverted from a vegan or vegetarian diet to a diet containing meat, or converted from eating meat to a vegetarian or vegan diet. Among those who had not changed their eating patterns over time, the largest weight gain was seen in meat-eaters. The smallest weight gain was observed in participants who converted to a vegetarian or vegan diet, and the highest weight gains were among participants classified as reverted, but mean weight gains were not different than weight gains in meat eaters.

Meat eaters had the highest prevalence of hypertension (HTN) and vegans the lowest in the EPIC cohort (Appleby, 2002), and vegetarians had lower blood pressure (BP) than omnivores in small

studies in Taiwan (Chen, 2008) and Brazil (Teixeira, 2007). Studies from Taiwan and Brazil also showed improvement in cardiovascular biomarkers, such as total cholesterol (TC), between individuals consuming vegetarian compared to omnivorous diets (Chen, 2008; Teixeira, 2007; Yen, 2008).

Vegans were found to have a higher risk of fractures than vegetarians and meat eaters in the EPIC cohort, which was related to the lower mean calcium intake in this group (Appleby, 2007). However, those on a vegetarian diet in Taiwan did not differ from non-vegetarians in bone mineral density (BMD) or risk of osteoporosis (Wang, 2008d). In a review of women from the Adventist Health Study (Thorpe, 2008), greater intake of foods rich in protein, whether from animal or plant sources, was associated with reduced wrist fractures.

Data on cancer are inconsistent with one recent study finding more colorectal cancer in vegetarians compared to meat eaters (Key, 2009a). However, the risk of female breast, prostate, ovarian and lung cancer were not significantly (NS) different between vegetarians and non-vegetarians.

Overall, Key and colleagues (2009b) found no differences in mortality rates between vegetarians and non-vegetarians in the EPIC cohort.

Evidence Summary Paragraphs

United Kingdom (Oxford cohort of the European Prospective Investigation into Cancer and Nutrition)

Appleby et al, 2002 (neutral quality). This cross-sectional study was designed to compare the prevalence of HTN and mean systolic blood pressure (SBP) and diastolic blood pressure (DBP) among 11,004 participants (2,351 men, 8,653 women) from the Oxford cohort of the European Prospective Investigation into Cancer and Nutrition (EPIC-Oxford). At baseline, all participants completed a detailed lifestyle questionnaire, including a semi-quantitative food frequency questionnaire (FFQ). Blood pressure was measured at their general practice. No standard method of BP measurement was specified and only single measurements were taken. Age at BP measurement ranged from 20 to 78 years (median=48 years in men and 46 years in women). Participants were 4,737 meat eaters, 1,728 fish eaters, 3,800 vegetarians and 739 vegans. Meat eaters had the highest mean energy intake, and consumed more protein, fat and saturated fat and less carbohydrate and polyunsaturated fat, than the other diet groups. Vegans consumed less saturated fat and calcium, had a higher P/S ratio compared with the other diet groups, and also had the lowest intakes of sodium from food. Meat eaters were the most likely and vegans the least likely, to use salt in cooking and at the table. There were significant differences in the age-adjusted prevalence of self-reported HTN among meat eaters, fish eaters, vegetarians and vegans for both men and women. Meat eaters had the highest and vegans the lowest prevalence of HTN, with fish eaters and vegetarians taking intermediate values. Among participants with no self-reported HTN, there were statistically significant variations in age-adjusted mean SBP and DBP between the four diet groups for both men and women, with meat eaters having the highest values and vegans the lowest values. The differences in age-adjusted mean BP between meat eaters and vegans among participants with no self-reported HTN were 4.2 and 2.6mmHg SBP and 2.8 and 1.7mmHg DBP for men and women, respectively. About half of the variation in BP was attributable to differences in body mass index (BMI), with non-dietary and macronutrient factors also accounting for some of the variation.

Spencer et al, 2003 (neutral quality). This cross-sectional study was designed to assess differences in BMI among participants from the Oxford cohort of the European Prospective Investigation into Cancer and Nutrition (EPIC-Oxford). Participants were 57,498 men and women recruited between 1993 and 1999. Participants completed a validated semi-quantitative FFQ and provided self-reported

height and weight. After applying exclusions due to ineligibility, recording error, missing or extreme values, and history of health conditions, 37,875 participants (8,871 men and 29,004 women) were included in analyses. Participants were primarily white adults between 20 and 97 years. Using answers from four questions, participants were divided into four diet groups: Meat eaters (eat meat), fish eaters (eat fish but not meat),vegetarians (do not eat meat or fish but do eat milk products or eggs) and vegans (eat no animal products). Meat-eaters had the highest intakes of energy, protein, total fat, saturated fat and monounsaturated fat and vegans had the highest intakes of fiber and polyunsaturated fats. Age-adjusted mean BMI was significantly different between the four diet groups: Highest in the meat-eaters (24.41kg/m^2 in men, 23.52kg/m^2 in women) and lowest in the vegans (22.49kg/m^2 in men, 21.98kg/m^2 in women); similar and intermediate for fish-eaters (23.30kg/m^2 in men, 22.66kg/m^2 in women) and vegetarians (23.37kg/m^2 in men, 22.71 in women). Prevalence of obesity was significantly lower in vegans than other diet groups; obesity rates significantly lower in vegetarians and fish-eaters than meat-eaters. After adjusting for all lifestyle and dietary factors included in this study, statistically significant differences in mean BMI between diet groups remained. High percent protein intake and low fiber intakes were the dietary factors most strongly associated with higher BMI between and within diet groups. The authors concluded that vegan diets, and to a less extent vegetarian diets and diets that include fish, are associated with lower BMI and lower levels of obesity than diets which include meat. However, they noted self-reported data and the use of a FFQ as limitations.

Rosell et al, 2006 (neutral quality). This prospective cohort was designed to assess changes in weight over five years among participants in the Oxford arm of the European Prospective Investigation into Cancer and Nutrition (EPIC-Oxford). Participants were 21,966 (5,373 men and 16,593 women) healthy adults aged 20-69 years at baseline who completed assessments between 1994 and 1999 and follow-up between 2000 and 2003 (median=5.3 years). Participants completed a FFQ and reported their height and weight. Participants were divided into six groups: Meat eaters (ate meat at both time points), fish eaters (ate fish but not meat at both time points), vegetarians (did not eat meat or fish but did eat diary or eggs at both time points), vegans (ate no animal products at either time point), reverted (those who changed diet in one or more steps in the direction of vegan to vegetarian to fish-eater to meat-eater) and converted (those who changed diet in one or more steps in the opposite direction). Mean annual weight gain was approximately 400 g per year. Differences were observed between the diet groups. A significantly smaller weight gain was observed among male and female vegans and female fish-eaters, compared to meat eaters. Among those who had not changed their eating patterns over time, the largest weight gain was seen in meat-eaters. The smallest weight gain was observed in people classified as converted. The highest weight gains were among men and women classified as reverted, but mean weight gains were not significantly different than weight gains in meat eaters. The lowest weight gain among this health-conscious cohort was seen among those individuals who had changed their diet to contain fewer animal foods. Additional analyses are reported on weight gain and non-dietary behaviors including physical activity and smoking.

Appleby et al, 2007 (neutral quality). This study was a prospective cohort study designed to examine fracture risk among meat eaters (N=19,249), fish eaters (N=4,901), vegetarians (N=9,420) and vegans (N=1,126) from the European Prospective Investigation into Cancer and Nutrition-Oxford (EPIC-Oxford) study. Of the 34,696 participants, 7,947 were men and 26,749 were women. Mean age at recruitment was 46.6 years. At baseline, participants completed a lifestyle and FFQ, including questions relating to height and weight, smoking habits, alcohol consumption, physical activity at work and during leisure time and marital status. Women were also asked about their reproductive history and use of hormone replacement therapy. Five years later, participants were sent a follow-up questionnaire that asked whether they had suffered any fractured bones over

the previous six years and to report the bones affected and the cause. Incident fracture was defined as one occurring after the date of recruitment and involving bones other than the digits or ribs. Over an average of 5.2 years of follow-up, 343 men and 1,555 women reported one or more fractures. Fracture risk was similar for meat eaters, fish eaters and vegetarians; compared with meat eaters, fracture incidence rate ratios in men and women combined adjusted for sex, age and non-dietary factors were 1.01 (95% CI: 0.88-1.17) for fish eaters, 1.00 (95% CI: 0.89-1.13) for vegetarians and 1.30 (95% CI: 1.02-1.66) for vegans. Mean calcium intakes were also similar for meat eaters, fish eaters and vegetarians, but were considerably lower for vegans. Percent of subjects consuming <700mg per day of calcium was 15.0 for meat eaters, 15.9 for fish eaters, 18.6 for vegetarians and 76.1 for vegans. The authors concluded that the higher fracture risk in the vegans appeared to result from their lower mean calcium intake.

Key et al, 2009a (positive quality). This study was a prospective cohort study designed to compare cancer incidence among participants in the European Prospective Investigation into Cancer and Nutrition-Oxford (EPIC-Oxford) study. Cancer incidence was followed through nationwide cancer registries to December 2005. Using answers from four questions, participants were divided into four diet groups: Meat eaters (eat meat), fish eaters (eat fish but not meat), vegetarians (do not eat meat or fish but do eat milk products or eggs) and vegans (eat no animal products). The overall cancer incidence in this cohort was lower than the national average. The analyses comparing vegetarian and non-vegetarian cancer incidence rates were restricted to 52,706 participants aged 20-89 years at recruitment with known smoking characteristics and diet group and no history of cancer at baseline (except non-melanoma skin cancer). Because of the small number of cancers among vegans, vegans were included in the vegetarian category for analyses. The risk of colorectal cancer was significantly higher among vegetarians than non-vegetarians (IRR: 1.49; 95% CI: 1.09, 2.03). The risk of female breast, prostate, ovarian and lung cancer were not significantly (NS) different between vegetarians and non-vegetarians. The risk of all malignant neoplasms was NS lower in vegetarians than in non-vegetarians (IRR: 0.93; 95% CI: 0.83, 1.04). The risk of all malignant neoplasms was significantly lower among fish eaters than meat eaters (IRR: 0.83; 95% CI: 0.71, 0.96). Meat intake among the meat eaters was moderate (78.1g per day in men and 69.7g per day in women). Fruit and vegetable intake was less than 20% higher among vegetarians than non-vegetarians. A possible limitation of the study is the accuracy of the assessment of diet classification.

Key et al, 2009b (positive quality). This study was a prospective cohort study designed to compare mortality from major causes of death among participants in the European Prospective Investigation into Cancer and Nutrition-Oxford (EPIC-Oxford) study. Death information was obtained from the United Kingdom's National Health Service Central Register. Using answers from four questions, participants were divided into four diet groups: Meat eaters (eat meat), fish eaters (eat fish but not meat),vegetarians (do not eat meat or fish but do eat milk products or eggs), and vegans (eat no animal products). Among 64,234 participants with known diet group, 2,965 died before age 90 by 30 June 2007. The death rate among participants was lower than the national average. The standardized mortality ratio for all causes of death was 52% (95% CI: 50%, 54%) and was identical between vegetarians and non-vegetarians. The analyses comparing diet groups were limited to 47,254 participants after applying exclusions for missing data and previous myocardial infarction (MI), stroke or malignant cancer (excluding non-melanoma skin cancer). Because of small number of deaths among vegans, vegans were included with vegetarians in the analyses. Comparisons between diet groups showed NS differences in mortality rates, but the authors stated that the study was not large enough to exclude small or moderate difference for specific causes of death. The authors also noted that the average meat intake among the meat eaters was moderate (79g per day in men, 67g per day in women) and differences in fruit and vegetable intake between vegetarians and non-vegetarians was also moderate (<20%). Subsequently, the low intake of meat and high intake of

fruits and vegetables among non-vegetarians in this cohort could reduce the chance of observing differences in mortality rates.

Taiwan

Hung et al, 2006 (neutral quality). This case-control study was designed to examine the effects of a Taiwanese vegetarian diet on hormonal secretion and glycemic control among female adults. Participants were 49 Buddhist lacto-vegetarians and 49 age-matched omnivores. The typical Taiwanese vegetarian diet consists mainly of rice, grains, fruits, vegetables, soybeans and soy products. The Western vegetarian diet contains more nuts, seeds, dairy and eggs. Dietary intakes were measured and hormone blood levels analyzed. Vegetarians consumed significantly less total fat (mean [SE]: 38.7 [2.65] vs. 49.9 [2.48] grams per day), saturated fat (mean [SE]: 8.34 [0.92] vs. 16.21 [1.10] grams per day) and protein (mean [SE]: 46.8 [2.23] vs. 64.5 [3.17] grams per day), but more fiber (mean [SE]: 6.57 [0.50] vs. 4.27 [0.45] grams per day) than omnivores. Total energy, carbohydrate and unsaturated fat intakes did not differ significantly. Percent of energy from protein, total fat, saturated fat and polyunsaturated fat were 12.2, 22.7, 4.9 and 11.5, respectively, for vegetarians; and 15.2, 26.4, 8.6 and 9.5, respectively, for omnivores. Vegetarians had significantly lower mean weight (mean [SE]: 51.5 [0.90] vs. 55.4 [0.85] kg) and waist circumference (WC) (mean [SE]: 64.2 [0.70] vs. 66.9 [0.67] cm), but BMI was NS different. Vegetarians had significantly lower fasting serum insulin (mean [SE]: 37.2 [1.81] vs. 56.6 [3.67] pmol/L), plasma glucose (mean [SE]: 4.7 [0.05] vs. 4.9 [0.05] mmol/L), insulin: glucagon ratio (mean [SE]: 0.37 [0.02] vs. 0.56 [0.05]) and HOMA-IR (mean [SE]: 1.09 [0.06] vs. 1.73 [0.11]) than omnivores. Body mass index and diet were independent predictors for insulin resistance and contributed 18 and 15% of the variation in insulin resistance, respectively. No significant difference in glucagon, beta-cell function, serum T3, free T4, TSH levels, or T3:T4 ratio was observed between groups. Young, female Taiwanese vegetarians had lower glucose and insulin and higher insulin sensitivity than omnivores.

Chen et al, 2008 (positive quality). This cohort study was designed to compare the cardiovascular risk profile of healthy Taiwanese vegetarians to omnivores. Participants were 99 vegetarians (34 male, 65 female; mean [SD] age=51.24 [8.88] years) and 99 omnivores (53 male, 46 female; 49.38 [9.60] years) who had undergone a general health exam at the Buddhist Dalin Tzu-Chi General Hospital. Participants completed questionnaires regarding past medical history and dietary preferences. Vegetarians were lacto-ovo vegetarians practicing for at least one year. After a 12-hour fast, venous blood samples were obtained; weight, height and BP were also measured. Differences in dietary intake between groups were not reported. Vegetarians had significantly lower TC, LDL-C, SBP and DBP than omnivores. There was NS difference in age, BMI, blood glucose, white blood cell count, triglyceride or HDL-C between the two diet groups. The authors concluded that Taiwanese vegetarians had a better cardiovascular risk profile than omnivores.

Wang et al, 2008 (positive quality). This cross-sectional analysis explored the effects of vegetarian and non-vegetarian diets on bone mineral density (BMD) and incidence of osteoporosis in adult Taiwanese men and women. Participants were 1,865 adult male and female participants who underwent a routine exam at a regional teaching hospital. Participants self-reported their dietary preference as vegetarian for at least five years (383 men, 489 women) or non-vegetarian (464 men, 529 women). Bone mineral density was measured using dual-energy X-ray absorptiometry (DXA) at the right femoral neck in men and between L-2 and L-4 vertebrae in women. Classifications of osteopenia and osteoporosis were based on World Health Organization (WHO) criteria. Bone mineral density gradually declined with increasing age in men, and declined precipitously in women after the fifth decade, but there were no statistical differences in BMD observed between vegetarians and non-vegetarians of either sex. The proportion of participants with osteopenia and osteoporosis

were also comparable between diet groups of both sexes. The authors concluded that there was an age-related decline in BMD, but a Taiwanese vegetarian diet did not appear to affect this decline. (Note: Dietary intake was not measured, but authors stated that the Taiwanese vegetarian diet typically contains large amounts of soybean products instead of milk, cheese and eggs.)

Yen et al, 2008 (positive quality). This cross-sectional study conducted in Taiwan, assessed and compared dietary intake and nutritional status of vegetarian and omnivorous pre-school children and their parents. Fifty-six omnivores (28 children and one of their parents) and 42 vegetarians (21 children and one of their parents) were included in the analysis. Among the preschool vegetarians, 18 were lacto-ovo vegetarians and three were ovo-vegetarians. Among the vegetarian parents, 16 were lacto-ovo vegetarians, two were ovo-vegetarians, one was lacto-vegetarian, and two were vegans. Anthropometric measurements were taken and fasting venous blood samples were obtained. Nutrient intake was recorded using three-day diet records. There were no differences between omnivores and vegetarians in terms of height, weight, BMI, weight-for-height index and triceps skinfold thickness values in both parent and child groups. All mean hematologic and biochemical nutrient status indices were within the reference range. However, both vegetarian parents and children had significantly lower mean TC and serum ferritin concentrations than those of omnivorous parents and children. Omnivorous children also had significantly higher HDL-C concentrations than vegetarian children. Most subjects had nutrient intakes above the Taiwan Dietary Reference Intakes (DRI). However, both vegetarians and omnivores in both parent and child groups had mean calcium consumption less than 75% of the Taiwan DRI. The authors concluded that vegetarian and omnivorous pre-school children had normal growth and adequate nutritional status. However, parents and children in both diet groups had inadequate calcium intakes.

United States

Thorpe et al, 2008 (positive quality). This cohort study was designed to examine the effects of meat consumption and a vegetarian diet on risk of low-energy wrist fracture in a cohort of peri- and post-menopausal women. Study participants (N=1865) were white female Seventh-day Adventists in the Adventist Health Study. Participants completed two lifestyle surveys 25 years apart (1976 and 2002). The survey included 65 semi-quantitative food items and data on fractures due to minor trauma at the wrist. The 25-year period-incidence rate for wrist fracture was 3.7 per 1,000 person-years. The group at highest risk for fracture were those who never ate meat and were also in the lowest category of vegetable protein intake. Among vegetarians, increasing vegetable protein intake reduced risk of fracture. Similarly, among those with the lowest vegetable protein consumption, consuming meat decreased risk of fracture. Vegetarians consumed more beans, nuts and meat analogues than non-vegetarians whereas cheese intake was higher for non-vegetarians. Higher consumption frequencies of foods rich in protein were associated with reduced wrist fractures. Vegetarian women were not at higher risk for wrist fracture than non-vegetarian women. The authors concluded that adequate protein intake is attainable in a vegetarian diet.

Australia

Baines et al, 2007 (positive quality). This cross-sectional study was designed to explore differences in sociodemographic characteristics, health status, and health service use among 9,113 young women (22-27 years old) in the Australian Longitudinal Study on Women's Health. Participants completed a survey that included items related to general health and well-being, health service use and health behaviors. All variables were self-reported. Participants were asked if they exclude red meat (beef, lamb, pork), fish or poultry from their diet. Non-vegetarians (87%) reported including red meat in their diet, semi-vegetarians (10%) excluded red meat from their diet and vegetarians (3%) excluded meat, poultry and fish from their diet. Vegetarians and semi-vegetarians had lower mean

BMI than non-vegetarians (22.2, 23.0 and 23.7kg/m^2, respectively) and tended to exercise more. The groups did not differ in their self-reported physical health; however, semi-vegetarians and vegetarians had poorer mental health, with 21-22% reporting depression compared with 15% of non-vegetarians (P<0.001). Significantly more vegetarians and semi-vegetarians reported (a) ever being diagnosed with low iron, iron deficiency or anemia, (b) constipation or other bowel problems, and (c) irregular periods than non-vegetarians.

Grant et al, 2008 (neutral quality). This cross-sectional analysis investigated possible relationships between nutrition and lifestyle behaviors and selected markers of health in 14 to 15-year-old Australian adolescents from Adventist secondary schools. 215 participants were recruited; complete data obtained for 207 participants (83 boys, 124 girls). Blood was drawn after a 12-hour overnight fast; height, weight and waist circumference (WC) were measured. Participants completed a school physical activity and nutrition survey. Participants were classified as vegetarian (N=53; 17 boys, 36 girls) if they reported consuming meat less than once a week, chicken less than once a week, and fish less than once a week; no participants were vegan. All other participants were classified as non-vegetarian (N=160; 69 boys, 91 girls). Participants following a vegetarian diet had significantly lower serum vitamin B_{12} (P<0.001), TC/HDL-C ratio (P<0.01), LDL-C (P<0.01), WC (P<0.01) and BMI (P<0.05) compared to non-vegetarians. No significant differences were observed between vegetarians and non-vegetarians in triglycerides, HDL-C, SBP, DBP or blood glucose. The authors concluded that a vegetable-rich diet may be an effective strategy for combating lifestyle diseases in adolescents.

Japan

Nakamoto et al, 2008 (neutral quality). This cross-sectional study conducted in Japan, investigated the nutritional characteristics of 75 healthy middle-aged vegetarians compared with 50 age- and sex-matched non-vegetarians. Of the vegetarians, 27 (nine men, 18 women) were lacto-ovo vegetarians and 48 (11 men, 37 women) were semi-vegetarians with the occasional intake of meat and seafood. Biochemical and anthropometric measurements were obtained from a medical examination. In men, vegetarians had significantly lower BMI, DBP, SBP and serum triacylglyceride than non-vegetarians. No significant difference in TC was observed in men. In women, vegetarians had significantly lower SBP and serum triacylglyceride than non-vegetarians. No significant differences in BMI, TC, or DBP were observed in women. Differences in dietary intake between vegetarians and non-vegetarians were also reported. Information on dietary intake (using three-day food record) was collected for 20 vegetarian men, 50 vegetarian women and 32 non-vegetarian men; the number of food records collected from non-vegetarian women was so small that their dietary intake data was dismissed. Vegetarian men had significantly higher intakes of calcium, iron and dietary fiber and significantly lower vitamin B_{12} and cholesterol than non-vegetarian men. The authors concluded that vegetarians had better characteristics from the standpoint of lifestyle related diseases, but cautioned that some nutrient intakes may be low in vegetarian men.

Sweeden

Newby et al, 2005 (neutral quality). This cross-sectional study was designed to examine the BMI and risk of overweight and obesity among self-defined omnivorous (consume all foods), semi-vegetarian (mostly lacto-vegetarian with some fish or eggs), lacto-vegetarian (no meat, poultry, fish or eggs) and vegan (no meat, poultry, fish, eggs or dairy) women. Participants were 55,459 healthy women from the Swedish Mammography Cohort who completed a FFQ, self-reported their height and weight, and identified their diet group. The majority of the participants were omnivores. Only 1.73% were semi-vegetarian, 0.29% were lacto-vegetarian and 0.15% were

vegan. The omnivores had significantly higher energy, protein,saturated fat, and monounsaturated fat intakes and significantly lower carbohydrate and fiber intake than the three vegetarian groups. Omnivores had the highest intake of refined grains and animal products and the lowest intake of fruits and vegetables. The prevalence of overweight and obesity (BMI$\geq 2$5kg/m^2) was 40% among omnivores, 29% among semi-vegetarians and vegans, and 25% among lacto-vegetarians. In multivariate, adjusted linear regression analyses, the semi-vegetarian, lacto-vegetarian, and vegan women had significantly lower BMI than omnivorous women. In multivariate, adjusted logistic regression analyses, all three vegetarian groups also had a significantly lower risk of overweight or obesity than the omnivores. Semi-vegetarian women also had a lower risk of obesity than omnivorous women. Self-identified semi-vegetarian, lacto-vegetarian and vegan women had a smaller BMI and lower risk of overweight and obesity than omnivorous women.Physical activity was not accounted for in analyses.

Belgium

Alewaeters et al, 2005 (neutral quality). This cross-sectional study was designed to report BMI and health behaviors of a vegetarian population as compared to a reference Belgian population. Vegetarian participants were 326 adults (120 men and 206 women) who were vegetarians for more than one year. Classification as vegetarian was confirmed by reviewing responses to a survey on dietary habits. The vegetarian group included vegans and those who consumed eggs or milk products. Vegetarians had a lower mean BMI compared to the reference population. The BMI of female vegetarians was significantly lower than the reference female Belgian population (mean [SD]=22.1 [3.1] and 24.6 [4.8] kg/m^2, respectively). Similarly, the BMI of male vegetarians was significantly lower than the reference male Belgian population (mean [SD]=22.6 [3.6] and 25.7 [4.0] kg/m^2, respectively). Other variables including smoking, alcohol consumption, physical activity, medication use and health perception were also compared between the vegetarians and reference Belgian population.

Brazil

Teixeira et al, 2007 (neutral quality). This comparative observational study in Brazil was designed to describe and analyze the cardiovascular risk of vegetarian and omnivorous adults aged 35 to 64 years. Sixty-seven vegetarians (practicing at least five years) completed assessments in 2003-2004. A total of 134 omnivores that were matched for age, gender, race and socioeconomic status were selected from a database of participants in the MONICA Project/Vitoria (1999-2000). The same methodology was used for data collection at both time points. Questionnaires were administered during home visits. Blood was drawn after 12-hour fasting for determination of lipid profile and fasting plasma glucose. Most of the vegetarians (73%) were lacto-ovo vegetarians. Body mass index, waist-to-hip ratio (WHR), BP, TC, LDL-C, triglycerides and fasting blood glucose were significantly lower among vegetarians than omnivores. There was no difference in HDL-C levels. Using the Framingham algorithm, vegetarians had a significantly lower cardiovascular risk than omnivores. Possible confounding factors include differences in BMI between groups and higher levels of smoking and consumption of alcoholic beverages in the omnivore group.

South Asian Immigrants In England

Dos Santos Silva et al, 2002 (positive quality). The case-control study was designed to investigate the role of lifelong vegetarianism on the etiology of breast cancer in South Asian migrant women living in England. Cases (N=240) were women of South Asian ethnic origin, <75 years old, with newly diagnosed breast cancer, born in Indian sub-continent or in East Africa and living and reporting to the Thames and West Midlands cancer registries during the study period and alive at the time of reporting. Controls (N=480) were individually matched to the case on year of birth within

five years and were randomly selected from all South Asian female patients born in the Indian sub-continent or East Africa who were registered with the same general practitioner as the case at diagnosis. Home interviews were conducted and included completion of an FFQ specifically designed for South Asian populations residing in England. Among controls, lifelong vegetarians had a much higher median daily intake of vegetables (332 g vs. 249g) and pulses, lentils and dhals (92g vs. 46g) than meat-eaters but similar consumption of fruit (1.6 servings vs. 1.6 servings) and bread (184g vs. 175g). Lifelong vegetarianism had a slight but not statistically significant reduction in the odds of breast cancer relative to lifelong meat eaters (OR=0.77, 95% CI: 0.50, 1.18). There was no linear trend in the odds of breast cancer with increasing meat intake, but there was a strong inverse linear trend with increasing intake of vegetables (P=0.005), pulses (P=0.007) and non-starch polysaccharides (P=0.02), but not with breads or fruits. The authors concluded that lifelong vegetarianism may be associated with a reduction in the risk of breast cancer through its association with a higher intake of vegetables and pulses.

⬕ View table in new window

Author, Year, Study Design, Class, Rating	Population / Subjects	Study Methodology	Outcomes
Alewaeters K, Clarys P et al, 2005 Study Design: Cross-Sectional Study Class: D Rating: ◔	N=326 vegetarians (120 men, 206 women) after exclusions. Participants were vegetarians >one year, ≥20 years of age and after looking at nutritional habits, did not eat meat including fish. Mean (SD) age: 42.3 (15.9) years for men; 37.0 (12.3) years for women. Reference Belgium population (N=9,659): Women N=4,993, age of 49.8 (18.0) years; men N=4,666, age of 48.0 (17.1) years. Location: Belgium.	Responses from 326 vegetarians were compared to the results from a survey of a representative sample of the Belgian population (N=9,659) conducted by the Belgian government. Vegetarians completed a self-administered questionnaire mainly comprised of questions from the National Health Survey (conducted in Belgium every five years) and self-reported their height and weight. Vegetarians were: • 79.8% lacto-ovo-vegetarians • 1.8% ovo-vegetarians • 2.1% lacto-vegetarians • 15% vegans.	BMI of female vegetarians was significantly lower than reference female Belgian population (mean [SD]=22.1 [3.1] and 24.6 [4.8] kg/m^2, respectively). BMI of male vegetarians was significantly lower than reference male Belgian population (mean [SD]=22.6 [3.6] and 25.7 [4.0] kg/m^2, respectively).

Appleby et al 2007 Study Design: Prospective Cohort Study Class: B Rating:	N=34,696 participants in the Oxford cohort of the European Prospective Investigation into Cancer and Nutrition (EPIC-Oxford) (7,947 men and 26,749 women) Age: 20-89 years (mean age at recruitment 46.6 years). N=19,249 meat eaters, 4,901 fish eaters, 9,420 vegetarians and 1,126 vegans in the analysis. Location: United Kingdom.	Participants completed a lifestyle and FFQ at baseline. Asked four yes/no questions: 1) Do you eat meat? 2) Do you eat fish? 3) Do you eat dairy products? 4) Do you eat eggs? Categorized into four groups: 1) Meat eaters (eat meat) 2) Fish eaters (eat fish, but not meat) 3) Vegetarians (do not eat meat or fish, but do eat diary or eggs) 4) Vegans (eat no animal products). Participants were sent follow-up questionnaire five years later (mean follow-up=5.2 years) that asked whether they had suffered any fractured bones over the previous six years and to report the bones affected and cause. Incident fracture was defined as one occurring after the date of recruitment and involving bones other than the digits or ribs.	At follow-up, 343 men and 1,555 women reported one or more fractures. Most common fracture sites: Wrist/arm and ankle; 70% of fractures caused by falls. Fracture risk similar for meat eaters, fish eaters and vegetarians; compared with meat eaters, fracture incidence rate ratios in men/women combined adjusted for sex, age and non-dietary factors were 1.01 (95% CI: 0.88-1.17) for fish eaters, 1.00 (95% CI: 0.89-1.13) for vegetarians and 1.30 (95% CI: 1.02-1.66) for vegans. Mean calcium intakes were also similar for meat eaters, fish eaters and vegetarians, but were considerably ↓ for vegans. Subjects consuming <700mg per day of calcium: • 15.0% for meat eaters • 15.9% for fish eaters • 18.6% for vegetarians • 76.1% for vegans.

Appleby, Davey et al, 2002 Study Design: Cross-sectional Class: D Rating:	Participants in the Oxford cohort of the European Prospective Investigation into Cancer and Nutrition (EPIC-Oxford). N=11,004 participants (2,351 men, 8,653 women) after exclusions: Date of BP measurement unknown or incomplete, >80 years, missing values of the BP measurements, BMI <15 or >60kg/m^2. • N=4,737 meat eaters • N=1,728 fish eaters • N=3,800 vegetarians • N=739 vegans. Age: At BP measurement ranged from 20 to 78 years (median 48 years men; 46 years women). Location: United Kingdom.	All participants completed a detailed lifestyle questionnaire, including a semi-quantitative FFQ. Asked four yes/no questions: 1) Do you eat meat? 2) Do you eat fish? 3) Do you eat dairy products? 4) Do you eat eggs? Categorized into four groups: • Meat eaters (eat meat) • Fish eaters (eat fish, but not meat) • Vegetarians (do not eat meat or fish, but do eat diary or eggs) • Vegans (eat no animal products). BP measured at their general practice. No standard method of BP measurement specified and only single measurements taken.	BMI was ↑ in the meat eaters than the vegans, with fish eaters and vegetarians having similar and intermediate values. Self-reported HTN was most common among meat eaters and least common among vegans. Age-adjusted prevalence for meat eaters, fish eaters, vegetarians and vegans, respectively, was 15.0%, 9.8%, 9.8% and 5.8% for men and 12.1%, 9.6%, 8.9% and 7.7% for women (each P<0.0005). The same pattern remained after further adjustment for BMI, although differences in prevalence of HTN between diet groups were smaller and of ↓ statistical significance (P=0.01 for men, P=0.07 for women). Significant differences in age-adjusted SBP and DBP between the diet groups for both men and women (each P<0.005). Meat eaters had the ↑ and vegans the ↓ adjusted mean values. Differences in age-adjusted mean BP between meat eaters and vegans among participants with no self-reported HTN were 4.2 and 2.6mmHg SBP

			and 2.8 and 1.7mmHg DBP for men and women, respectively; this variation was largely attributable to differences in BMI between groups.
Baines et al 2007 Study Design: Cross-sectional Analysis of Cohort Study Class: D Rating: ⊕	N=9,113 women from the Australian Longitudinal Study on Women's Health. Age: 22-27 years. Location: Australia.	Self-reported survey. Participants asked: Do you exclude any of the following food groups from your diet? a) Red meat (beef, lamb, pork) b) Fish c) Poultry. Non-vegetarians (87%) reported including red meat in their diet; semi-vegetarians (10%) excluded red meat from their diet; vegetarians (3%) excluded meat, poultry and fish from their diet.	Vegetarians (mean=22.2, 95% CI: 21.7-22.7) and semi-vegetarians (mean=23.0, 95% CI: 22.7-23.3kg/m^2) had ↓ BMI than non-vegetarians (mean=23.7, 95% CI: 23.6-23.8kg/m^2) and tended to exercise more. Groups did not differ in self-reported physical health; however, semi-vegetarians and vegetarians had poorer mental health, with 21-22% reporting depression compared with 15% of non-vegetarians (P<0.001). Significantly more vegetarians (42.6%) and semi-vegetarians (38.9%) reported ever being diagnosed with low iron, iron deficiency or anemia than non-vegetarians (25.5%). Significantly more vegetarians (29.1%) and semi-vegetarians (27.5%) reported constipation or other bowel problems than non-vegetarians (22.7%).

			Significantly more vegetarians (27.5%) and semi-vegetarians (25.0%) reported irregular periods than non-vegetarians (18.7%).
Chen et al 2008 Study Design: Cohort study Class: B Rating: ➕	N=99 vegetarians (34 male, 65 female; mean [SD] age=51.24 [8.88] years). N=99 omnivores (53 male, 46 female; 49.38 [9.60] years). Location: Taiwan.	Participants had undergone general health exam at the Buddhist Dalin Tzu-Chi General Hospital. Questionnaires were completed regarding past medical history, dietary preferences and willingness to participate in the study and were enrolled if they met inclusion criteria. Patients with a history of DM, HTN, CVD, dyslipidemia, chronic gingivitis, rheumatoid arthritis or other connective tissue disease, CAD and fever or other infectious disease within three weeks before the start of the study were excluded. Vegetarians were lacto-ovo-vegetarians for ≥one year. After 12-hour fast, venous blood samples were obtained; weight, height and BP were also measured.	NS difference in age, BMI, blood glucose, white blood cell count, TG or HDL-C between the two groups. Vegetarians had significantly ↓ TC (mean [SD]: 184.74 [33.23] vs. 202.01 [41.05] mg/dL) and LDL-C (119.63 [31.59] vs. 135.89 [39.50] mg/dL) than omnivores. Vegetarians had significantly ↓ SBP (mean [SD]: 120.49 [15.63] vs. 125.55 [15.04]) and DBP (75.01 [11.90] vs. 78.76 [11.71]) than omnivores.
Dos Santos Silva et al 2002 Study Design: Case-Control Study Class: C	N=240 cases with newly diagnosed breast cancer and 480 controls. Mean age: 51.45 years for cases; 51.87 years for controls. Location: England.	Cases were women of South Asian ethnic origin, <75 years old, with newly diagnosed breast cancer, born in Indian sub-continent or in East Africa and living and reported to the Thames and West Midlands cancer registries during the study	Among controls, lifelong vegetarians had a much ↑ median daily intake of vegetables (332g vs. 249g) and pulses, lentils and dhals (92g vs. 46g) than meat-eaters, but similar consumption of fruit (1.6 servings vs. 1.6

Rating: ⊕		period and alive at time of the reporting. Controls individually matched to the case on year of birth within five years and were randomly selected from all South Asian female patients born in the Indian sub-continent or East Africa who were registered with the same general practitioner as the case at diagnosis. Exclusion criteria: Previous diagnosis of any cancer, suffering from conditions requiring strict diets, or suffering from mental or psychiatric disorders. Home interviews conducted and included completion of an FFQ specifically designed for South Asian populations residing in England.	servings) and bread (184g vs. 175g). Lifelong vegetarianism had a slight, but not statistically significant ↓ in the odds of breast cancer relative to lifelong meat eaters (OR=0.77, 95% CI: 0.50, 1.18). No linear trend in the odds of breast cancer with ↑ meat intake, but a strong inverse linear trend with ↑ intake of vegetables (P=0.005), pulses (P=0.007) and non-starch polysaccharides (P=0.02), but not with breads or fruits.
Grant et al 2008 Study Design: Cross-Sectional Analysis of a Cohort Class: D Rating: ◐	N=215 participants recruited; complete data existed for 207 participants (124 girls, 83 boys). Age: 14 to 15-year-old adolescents from Adventist secondary schools. Location: Australia	Blood drawn after a 12-hour overnight fast; height, weight and WC measured. Participants completed a school physical activity and nutrition survey. Vegetarians: N=53 (17 boys, 36 girls); diet was "vegetable-rich"; participants were classified as vegetarian if consumed meat <once a week, chicken <once a week, and fish <once a week; no participants were vegan. Non-vegetarians: N=160 (69 boys, 91 girls).	Vegetarians significantly lower values for the following variables than non-vegetarians (mean values): • WC (69.2 vs. 73.5cm) • BMI (20.5 vs. 21.9kg/m^2) • TC/HDL-C ratio (2.7 vs. 2.9) • LDL-C (2.1 vs. 2.3 mmol/L) • Serum B$_{12}$ (260 vs. 339 pmol/L). NS difference between vegetarians and non-vegetarians in TG, HDL-C, SBP, DBP or

			blood glucose.
Hung CJ, Huang PC et al, 2006 Study Design: Case Control Study Class: C Rating: ◔	N=98 females (49 Buddhist lacto-vegetarians; 49 age-matched omnivores). Age: 31-45 years; pre-menopausal. Within 120% of IBW; no history of chronic disease (e.g., heart disease, DM, cancer, HTN, renal disease); and no alcohol intake or cigarette smoking. Among vegetarians, seven were vegans and 42 were lacto-vegetarians who consumed <240ml low-fat or skim milk daily; average vegetarian practice was eight years with minimum of two years. Location: Taiwan.	Dietary intake assessed using 24-hour recall supplemented with semi-quantitative FFQ. Nutrient data calculated using a database for Taiwan food composition. After an overnight fast of 10-11 hours, anthropometric measurements were performed and blood samples were collected.	Vegetarians consumed significantly ↓ total fat (mean [SE]: 38.7 [2.65] vs. 49.9 [2.48] g per day), saturated fat (mean [SE]: 8.34 [0.92] vs. 16.21 [1.10] g per day) and PRO (mean [SE]: 46.8 [2.23] vs. 64.5 [3.17] g per day), but more fiber (mean [SE]: 6.57 [0.50] vs. 4.27 [0.45] g per day) than omnivores. Total energy, CHO and unsaturated fat intakes NS different. Vegetarians had significantly ↓ mean weight (mean [SE]: 51.5 [0.90] vs. 55.4 [0.85] kg) and WC (mean [SE]: 64.2 [0.70] vs. 66.9 [0.67] cm), but BMI was NS different. Vegetarians had significantly ↓ mean weight (mean [SE]: 51.5 [0.90] vs. 55.4 [0.85] kg) and WC (mean [SE]: 64.2 [0.70] vs. 66.9 [0.67] cm), but BMI was NS different. Vegetarians had significantly ↓ fasting serum insulin (mean [SE]: 37.2 [1.81] vs. 56.6 [3.67] pmol/L), plasma glucose (mean [SE]: 4.7 [0.05] vs. 4.9 [0.05] mmol/L), insulin: glucagon ratio (mean

			[SE]: 0.37 [0.02] vs. 0.56 [0.05]) and HOMA-IR (mean [SE]: 1.09 [0.06] vs. 1.73 [0.11]) than omnivores. BMI and diet were independent predictors for insulin resistance and contributed 18 and 15% of the variation in insulin resistance, respectively. NS difference in glucagon, beta-cell function, serum T3, free T4, TSH levels, or T3:T4 ratio observed between groups.
Key TJ, Appleby PN et al, 2009 Study Design: Prospective Cohort Study Class: B Rating: ⊕	Participants in the European Prospective Investigation into Cancer and Nutrition-Oxford (EPIC-Oxford) study. N=63,550 men and women included in the analyses comparing cancer incidence with national rates for England and Wales. N=52,706 men and women included in the analyses comparing vegetarians and non-vegetarians (32% vegetarians; 77% women). Age: 20-89 years at recruitment. Known smoking status; no history of cancer at baseline.	Prospective cohort study from 1990s to December 2005. Cancer incidence from nationwide cancer registries. Asked four yes/no questions: 1) Do you eat meat? 2) Do you eat fish? 3) Do you eat dairy products? 4) Do you eat eggs? Categorized into four groups: 1) Meat eaters (eat meat) 2) Fish eaters (eat fish, but not meat) 3) Vegetarians (do not eat meat or fish, but do eat diary or eggs) 4) Vegans (eat no animal products). Because of small number of cancers among vegans, vegans included with	N=2,179 incident cancers before age 90; overall cancer incidence ↓ than national average. Vegetarians to non-vegetarians: Risk of colorectal cancer significantly ↑ among vegetarians (IRR:1.49; 95% CI: 1.09, 2.03); risk at other cancer sites (female breast, prostate, ovarian, and lung) NS difference. Meat eaters, fish eaters and vegetarians: Colorectal cancer significantly ↑ in vegetarians than meat eaters (IRR: 1.39; 95% CI: 1.01, 1.91); risk of lung cancer significantly ↓ in fish eaters than meat eaters (IRR: 0.23; 95% CI: 0.06, 0.95); risk of all malignant neoplasms significantly ↓ among

	Location: United Kingdom.	vegetarians in analyses.	fish eaters than meat eaters (IRR: 0.83; 95% CI: 0.71, 0.96). Risk of all malignant neoplasms NS ↓ in vegetarians than non-vegetarians (IRR: 0.93; 95% CI: 0.83, 1.04); risk of all malignant neoplasms NS ↓ among vegetarians than meat eaters (IRR: 0.89; 95% CI: 0.80, 1.00).
Key TJ, Appleby PN et al, 2009 Study Design: Prospective cohort study Class: B Rating: ⊕	Participants in the Oxford cohort of the European Prospective Investigation into Cancer and Nutrition (EPIC-Oxford). N=64,234 participants aged 20-89 years included in the analyses comparing mortality with national rates for England and Wales. N=47,254 participants included in comparisons between diet groups (after applying exclusions for missing data, previous MI or stroke, or malignant cancer [excluding non-melanoma skin cancer]); 76% women, 34% vegetarians. Location: United Kingdom.	Participants recruited between 1993 and 1999. Self-reported dietary intake using a validated semi-quantitative FFQ. Death information from UK's National Health Service Central Register. Asked four yes/no questions: 1) Do you eat meat? 2) Do you eat fish? 3) Do you eat dairy products? 4) Do you eat eggs? Categorized into four groups: • Meat eaters (eat meat) • fish eaters (eat fish, but not meat) • Vegetarians (do not eat meat or fish, but do eat diary or eggs) • Vegans (eat no animal products). Because of small number of deaths among vegans, vegans included with vegetarians in analyses.	Among 64,234 participants, 2,965 had died before age 90 by 30 June 2007; death rate lower than average for the UK; standardized mortality ratio for all causes of death was 52% (95% CI: 50%, 54%) and was identical in vegetarians and non-vegetarians. Among 47,254 participants, there was NS difference in mortality rates between non-vegetarians and vegetarians or between meat eaters, fish eaters and vegetarians.

Nakamoto et al 2008 Study Design: Cross-sectional Study Class: D Rating: ◓	N=75 healthy middle-aged vegetarians, compared with 50 age- and sex-matched non-vegetarians. Information on dietary intake was collected for: - 20 vegetarian men (age, mean [SD]=45.2 [8.3] years) - 50 vegetarian women (45.9 [8.8] years) - 32 non-vegetarian men (44.2 [5.2] years) Number of food records collected from non-vegetarian women was so small that their dietary intake data was dismissed. Location: Japan.	Of the vegetarians, 27 (9 men, 18 women) were lacto-ovo-vegetarians and 48 (11 men, 37 women) were semi-vegetarians with the occasional intake of meat and seafood (none were vegan). Biochemical and anthropometric measurements were obtained from a medical examination. Participants kept a three-day food record; the average one-day intake over three days was used.	In men, vegetarians had significantly ↓ values than non-vegetarians for the following variables (mean values): - BMI (21.4 vs. 23.2kg/m^2). - DBP (71.7 vs. 83.3mmHg). - SBP (118.3 vs. 129.4mmHg). - Serum TG (119.6 vs. 228.8mg/dL). NS difference in TC. In women, vegetarians had significantly ↓ values than non-vegetarians for the following variables: - SBP (111.7 vs. 118.4mmHg) - Serum TG (85.9 vs. 133.7mg/dL). NS differences in TC, BMI or DBP. Differences in dietary intake between vegetarians and non-vegetarians men were also reported. For e.g., vegetarian men had significantly ↑ intakes of calcium, iron and dietary fiber and significantly ↓ vitamin B$_{12}$ and cholesterol than non-vegetarian men.

Newby PK, Tucker KL et al, 2005 Study Design: Cross-Sectional Study Class: D Rating: ◔	N=55,459 healthy women in Swedish Mammography Cohort after applying exclusions for missing or implausible values and history of angina, DM, CHD, cancer and stroke. Mean (SD) age: Four diet groups ranged from 51.1 (9.5) to 54.8 (9.5) years. Location: Sweden.	Cross-sectional study between 1987 and 1990. FFQ; self-reported height and weight. Women asked if they considered themselves: 1) Omnivores (consume all foods, N=54,257) 2) Semi-vegetarians (mostly lacto-vegetarian with some fish or eggs, N=960) 3) Lacto-vegetarians (no meat, poultry, fish or eggs, N=159) 4) Vegans (no meat, poultry, fish, eggs or dairy, N=83).	Prevalence of overweight and obesity (BMI≥25kg/m^2): • 40% among omnivores • 29% among semi-vegetarians and vegans • 25% among lacto-vegetarians. In multivariate, adjusted linear regression analyses, semi-vegetarian (b= -1.13; 95% CI: -1.42, -0.84), lacto-vegetarian (b= -1.07; 95% CI: -1.81, -0.33) and vegan (b= -1.29; 95% CI: -2.33, -0.25) women had significantly ↓ BMI than omnivores. In multivariate, adjusted logistic regression analyses, semi-vegetarians (OR=0.52; 95% CI: 0.43, 0.62), lacto-vegetarians (OR=0.54; 95% CI: 0.35, 0.85) and vegans (OR=0.35; 95% CI: 0.18, 0.69) had a significantly ↓ risk of overweight or obesity than omnivores. Semi-vegetarians had a ↓ risk of obesity (OR=0.46; 95% CI: 0.31, 0.66) than omnivores.
Rosell M, Appleby P et al, 2006 Study Design:	Participants in the Oxford cohort of the European Prospective Investigation into Cancer and Nutrition	Prospective cohort; recruitment 1994 to 1999 and follow-up 2000 to 2003 (median duration 5.3 years, range 3.2-9.1 years).	Mean (SD) annual weight gain was 389 (884)g in men and 398 (892)g in women.

Prospective Cohort Study Class: B Rating: ◗	(EPIC-Oxford). N=21,966 (5,373 men and 16,593 women) after applying exclusions for missing and extreme data, weight Δ >20kg, ≥70 years, suffered a stroke, heart attack, angina, malignant neoplasm or DM at baseline and if diet group was unclear. Mean (SD) age: 46.1 (11.5) years men; 43.1 (11.8) years women. Location. United Kingdom.	FFQ and self-reported height and weight. Asked four yes/no questions at baseline and follow-up: 1) Do you eat meat? 2) Do you eat fish? 3) Do you eat dairy products? 4) Do you eat eggs? Categorized into six groups based on responses: 1) Meat eaters (ate meat at both time points) 2) Fish eaters (ate fish, but not meat at both time points) 3) Vegetarians (did not eat meat or fish, but did eat diary or eggs at both time points) 4) Vegans (ate no animal products at either time point) 5) Reverted (Δ diet in one or more steps in the direction of vegan to vegetarian to fish-eater to meat-eater) 6) Converted (Δ their diet in one or more steps in the direction of meat-eater to fish-eater to vegetarian to vegan).	Differences in mean BMI between meat eaters, fish eaters, vegetarians and vegans at follow-up were similar to those seen at baseline. Compared with meat eaters, mean annual weight gain was significantly ↓ in vegans (284g in men and 303g in women, P<0.05 for both sexes) and fish-eaters (338g, P<0.001 for women only). Men and women classified as converted showed the smallest mean annual weight gain of 242 (95% CI: 133-351) and 301 (95% CI: 238-365)g, respectively. Highest weight gains were among men and women classified as reverted, but mean weight gains were NS different than weight gains in meat eaters.
Spencer EA, Appleby PN et al, 2003 Study Design: Cross-Sectional Study Class: D	Participants in the Oxford cohort of the European Prospective. Investigation into Cancer and Nutrition (EPIC-Oxford). N=57,498 men and women recruited.	Self-reported dietary intake using a validated semiquantitative FFQ. Asked four yes/no questions: 1) Do you eat meat? 2) Do you eat fish? 3) Do you eat dairy products?	Men (overall): Mean BMI=23.81kg/m^2; 8% underweight (BMI<20kg/m^2), 61% normal weight (BMI 20-24.9kg/m^2), 27% overweight (BMI 25-29.9kg/m^2) and 4% obese (BMI≥30kg/m^2).

Rating: ⬤	N=37,875 (8,871 men and 29,004 women, after applying exclusions due to ineligibility, recording error, missing or extreme values, or history of MI, stroke, angina, HBP, high cholesterol, DM, gallstones, polyps or cancer). Age: 20-97 years (median age=43 years men; 40 years women), primarily white. Location: United Kingdom.	4) Do you eat eggs? Categorized into four groups: • Meat eaters (eat meat) • Fish eaters (eat fish, but not meat) • Vegetarians (do not eat meat or fish, but do eat diary or eggs) • Vegans (eat no animal products). BMI calculated from self-reported weight to the nearest 0.1kg and height to the nearest cm. Questionnaires administered at baseline between 1993 and 1999.	Women (overall): Mean BMI=23.05kg/m^2; 16% underweight, 63% normal weight, 17% overweight, and 5% obese. Age-adjusted mean BMI significantly different between four diet groups: Highest in the meat-eaters (24.41kg/m^2 in men, 23.52kg/m^2 in women) and ↓ in vegans (22.49kg/m^2 in men, 21.98kg/m^2 in women); similar and intermediate for fish-eaters (23.30kg/m^2 in men, 22.66kg/m^2 in women) and vegetarians (23.37kg/m^2 in men, 22.71 in women). Prevalence of obesity significantly ↓ in vegans than other diet groups; obesity rates significantly ↓ in vegetarians and fish-eaters than meat-eaters. After adjusting for all lifestyle and dietary factors included in this study, statistically significant differences in mean BMI between diet groups remained. High percent protein intake and low fiber intakes were the dietary factors most strongly associated with higher BMI between and within diet groups.

Teixeira Rde C, Molina Mdel C et al, 2007 Study Design: Prospective Cohort Study Class: B Rating: ●	N=67 vegetarians and 134 omnivores matched for age, gender, race, and socioeconomic status. Mean (SD) age: 47 (eight) years. Mostly white or of mixed race. Location: Brazil.	Vegetarians completed assessments in 2003-2004; omnivores were part of the MONICA Project/Vitoria conducted in 1999-2000; data collection methods were the same at both time points. Participants completed socioeconomic, health, eating habits and physical activity questionnaire during home visit. Blood drawn after 12-hour fast for determination of lipid profile and fasting plasma glucose. Vegetarians reported no meat intake in at least the last five years; omnivores reported that they did not refrain from eating meat. Mean (SD) duration of vegetarianism=19 (10) years: ● 73% lacto-ovo-vegetarians ● 3% lacto-vegetarians ● 10% pesco-vegetarians ● 14% strict vegetarians.	BMI significantly ↓ in vegetarians than omnivores, mean (SD)=22.6 (3.1) and 26.7 (5.1)kg/m^2, respectively. WHR significantly ↓ in vegetarians than omnivores, mean (SD)=0.82 (0.08) and 0.88 (0.09), respectively. Mean SBP and DBP significantly ↓ among vegetarians than omnivores, SBP: mean (SD)=108 (16) and 129 (19) mmHg, respectively; DBP: mean (SD)=71 (10) and 86 (13) mmHg, respectively. TC significantly ↓ among vegetarians than omnivores, mean (SD)=173 (36) and 225 (45) mg/dL, respectively. LDL-C significantly ↓ among vegetarians than omnivores, mean (SD)=106 (35) and 151 (43) mg/dL, respectively. TG significantly ↓ among vegetarians than omnivores, mean (SD)=113 (79) and 156 (127) mg/dL, respectively. HDL-C of vegetarians (mean (SD)=45.2 (10)) and omnivores (mean (SD)=45.7 (12)) did not differ significantly. Fasting plasma glucose significantly ↓ among

			vegetarians than omnivores, mean (SD)=82 (10) and 108 (37) mg/dL, respectively; those with levels above 125mg/dL= zero vegetarians and 14 omnivores. Total cardiovascular risk (using Framingham algorithm) significantly ↓ among vegetarians. Risk of CAD in ten years: Among vegetarians, 93% classified as low risk; 7% as medium risk. Among omnivores, 63% classified as low risk; 27% as medium risk; 10% as high risk.
Thorpe DL, Knutsen SF et al, 2008 Study Design: Prospective Cohort Study Class: B Rating: 🟢	N=1,865 non-Hispanic White, Seventh-day Adventist women who were part of the Adventist Health Study. N=1,406 menopausal at baseline (including surgical menopause and early menopause) and 459 peri-menopausal. Location: United States.	Cohort study of women who completed two lifestyle surveys 25 years apart. In Adventist Health Study 1 (1976), participants completed a lifestyle survey. In Adventist Health Study 2 (2002), participants were recruited and 14 variables (e.g., name and date of birth) from the survey were used to match participants from AHS 1 to AHS 2. The survey included 65 semi-quantitative food items and data on fractures due to minor trauma at the wrist.	The 25-year period-incidence rate for wrist fracture was 3.7 per 1,000 person-years. Those at highest risk of fracture were those who never consume meat and were in the lowest category of vegetable protein intake. Among vegetarians, ↑ vegetable protein ↓ risk of fracture by 68% (HR=0.32, 95% CI 0.13-0.79) in the highest intake group. Among those with lowest vegetable PRO intake, ↑ meat intake ↓ risk of wrist fracture by 80% (HR=0.20, 95% CI 0.06-0.66) in the highest

			intake group.
			Six foods ↑ in protein were identified in the survey: Cheese, beans, nuts, meat analogues, vegetable protein analogues, meat and fruits and vegetables.
			Cheese and meat intake were protective against wrist fracture in a dose-response manner.
			Vegetable PRO food group intake did not show an independent effect on fracture risk.
			In vegetarians, risk of wrist fracture ↓ with frequency of consumption for each food ↑ in PRO. For non-vegetarians, risk tended to ↓ with meat consumption and ↑ with intake of each plant-based PRO food.
Wang et al 2008 Study Design: Cross-sectional Analysis of Retrospective Cohort Class: D Rating: ⊕	N=1,865 adult male and female patients who underwent a routine exam at a regional teaching hospital. Specific age not specified, range of 21 years to 89 years. Exclusion criteria: Notable osteopathy, scoliosis or poor posture, degenerative Δ of the spinal cord and surgically or medically-induced	Self-reported dietary preference as vegetarian (for at least five years) or non-vegetarian: • 383 vegetarian men • 464 non-vegetarian men • 489 vegetarian women • 529 non-vegetarian women. BMD measured using DXA at right femoral neck (men) and between L-2 and L-4 vertebrae (women). Classifications of osteopenia and osteoporosis based on	BMD gradually ↓ with ↑ age in men and ↓ precipitously in women after the fifth decade, but there were no statistical differences in BMD observed between vegetarians and non-vegetarians of either sex. The proportion of participants with osteopenia and osteoporosis were also comparable between diet groups of both sexes.

	medically-induced menopause. Location: Taiwan.	WHO criteria. Dietary intake was not measured, but authors noted that the Taiwanese vegetarian diet typically contains large amounts of soybean products instead of milk, cheese and eggs.	
Yen et al 2008 Study Design: Cross-sectional Study Class: D Rating: ⊕	N=56 omnivores (28 children and one of their parents) and 42 vegetarians (21 children and one of their parents) were included in the analysis. Mean (SD) age and male/female: • Omnivore parents: 35.9 (4.1) years, 9/19 • Vegetarian parents: 34.8 (4.5) years, 4/17 • Omnivore children: 5.0 (1.1) years, 15/13 • Vegetarian children: 5.2 (1.5) years, 14/7. Location: Taiwan.	Anthropometric measurements were taken; BMI and weight-for-height index (WHI) were calculated. Nutrient intake was recorded using three-day dietary records. Fasting venous blood samples were obtained. Vegetarians: Among 21 preschool children • 18 lacto-ovo-vegetarians • Three ovo-vegetarians. Among 21 parents • 16 lacto-ovo-vegetarians • Two ovo-vegetarians • One lacto-vegetarian • Two vegans. Vegetarian parents and children had been following this diet practice for a mean of 8.8 and 4.5 years (range one to 35 and one to seven years, respectively).	No differences between omnivores and vegetarians in terms of height, weight, BMI, WHI and triceps skinfold thickness values in both parent and child groups. All mean hematologic and biochemical nutrient status indices were within the reference range; However, both vegetarian parents and children had significantly ↓ mean TC and serum ferritin concentrations than those of omnivorous parents and children: Parent TC for vegetarians and non-vegetarians, respectively: 159.4 vs. 187.2mg/dL. Child TC for vegetarians and non-vegetarians, respectively: 143.5 vs. 166.3mg/dL. Parent serum ferritin for vegetarians and non-vegetarians, respectively: 45.6 vs. 103.5ng/ml. Child serum ferritin for vegetarians and

| | | | non-vegetarians, respectively: 26.6 vs. 38.7ng/ml.

Omnivorous children had significantly ↑ HDL-C than vegetarian children (57.6 vs. 48.3mg/dL).

Most subjects had nutrient intakes above the Taiwan DRI; however, vegetarians and omnivores in both parent and child groups had mean calcium consumption <75% of the Taiwan dietary intakes.

Both omnivorous parents and their children had significantly ↑ fat and ↓ fiber intakes than vegetarian parents and children.

Omnivorous children had significantly ↑ PRO and ↓ vitamin C intakes than vegetarian children, whereas omnivorous parents had significantly ↓ vitamin A and iron intakes than vegetarian parents. |

Research Design and Implementation Rating Summary

For a summary of the Research Design and Implementation Rating results, click here.

Worksheets

Alewaeters K, Clarys P, Hebbelinck M, Deriemaeker P, Clarys JP. Cross-sectional analysis of BMI and some lifestyle variables in Flemish vegetarians compared with non-vegetarians. *Ergonomics.* 2005 Sep 15-Nov 15; 48(11-14): 1,433-1,444.

Appleby P, Roddam A, Allen N, Key T. Comparative fracture risk in vegetarians and nonvegetarians in EPIC-Oxford. *Eur J Clin Nutr.* 2007 Dec;61(12):1400-6.

Appleby PN, Davey GK, Key TJ. Hypertension and blood pressure among meat eaters, fish eaters, vegetarians and vegans in EPIC-Oxford. *Public Health Nutr*. 2002 Oct; 5 (5): 645-654.

Baines S, Powers J, Brown WJ. How does the health and well-being of young Australian vegetarian and semi-vegetarian women compare with non-vegetarians? *Public Health Nutr*. 2007 May;10(5):436-42.

Chen CW, Lin YL, Lin TK, Lin CT, Chen BC, Lin CL. Total cardiovascular risk profile of Taiwanese vegetarians. *Eur J Clin Nutr*. 2008 Jan;62(1):138-44. Epub 2007 Mar 14.

Dos Santos Silva I, Mangtani P, McCormack V, Bhakta D, Sevak L, McMichael AJ. Lifelong vegetarianism and risk of breast cancer: a population-based case-control study among South Asian migrant women living in England. *Int J Cancer*. 2002 May 10;99(2):238-44.

Grant R, Bilgin A, Zeuschner C, Guy T, Pearce R, Hokin B, Ashton J. The relative impact of a vegetable-rich diet on key markers of health in a cohort of Australian adolescents. *Asia Pac J Clin Nutr*. 2008;17(1):107-15.

Hung CJ, Huang PC, Li YH, Lu SC, Ho LT, Chou HF. Taiwanese vegetarians have higher insulin sensitivity than omnivores. *Br J Nutr*. 2006 Jan; 95(1): 129-135.

Key TJ, Appleby PN, Spencer EA, Travis RC, Roddam AW, Allen NE. Mortality in British vegetarians: Results from the European Prospective Investigation into Cancer and Nutrition (EPIC-Oxford). *Am J Clin Nutr*. 2009 May; 89 (5): 1,613S-1,619S. Epub 2009 Mar 18.

Key TJ, Appleby PN, Spencer EA, Travis RC, Roddam AW, Allen NE. Cancer incidence in vegetarians: Results from the European Prospective Investigation into Cancer and Nutrition (EPIC-Oxford). *Am J Clin Nutr*. 2009 May; 89(5): 1,620S-1,626S. Epub 2009 Mar 11.

Nakamoto K, Watanabe S, Kudo H, Tanaka A. Nutritional characteristics of middle-aged Japanese vegetarians. *J Atheroscler Thromb*. 2008 Jun;15(3):122-9.

Newby PK, Tucker KL, Wolk A. Risk of overweight and obesity among semi vegetarian, lactovegetarian and vegan women. *Am J Clin Nutr*. 2005 Jun; 81 (6): 1,267-1,274.

Rosell M, Appleby P, Spencer E, Key T. Weight gain over five years in 21, 966 meat-eating, fish-eating, vegetarian and vegan men and women in EPIC-Oxford. *Int J Obes* (Lond). 2006 Sep; 30 (9): 1,389-1,396.

Spencer EA, Appleby PN, Davey GK, Key TJ. Diet and body mass index in 38000 EPIC-Oxford meat-eaters, fish-eaters, vegetarians and vegans. *Int J Obes Relat Metab Disord*. 2003 Jun; 27(6): 728-734.

Teixeira Rde C, Molina Mdel C, Zandonade E, Mill JG. Cardiovascular risk in vegetarians and omnivores: A comparative study. *Arq Bras Cardiol*. 2007 Oct; 89 (4): 237-244. English, Portuguese.

Thorpe DL, Knutsen SF, Beeson WL, Rajaram S, Fraser GE. Effects of meat consumption

and vegetarian diet on risk of wrist fracture over 25 years in a cohort of peri- and postmenopausal women. *Public Health Nutr.* 2008 Jun; 11 (6): 564-572. Epub 2007 Aug 9.

Wang YF, Chiu JS, Chuang MH, Chiu JE, Lin CL. Bone mineral density of vegetarian and non-vegetarian adults in Taiwan. *Asia Pac J Clin Nutr.* 2008;17(1):101-6.

Yen CE, Yen CH, Huang MC, Cheng CH, Huang YC. Dietary intake and nutritional status of vegetarian and omnivorous preschool children and their parents in Taiwan. *Nutr Res.* 2008 Jul;28(7):430-6.